Pullen Creek Watershed Planning

For:
Skagway Traditional Council

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In every respect, the valley rules the stream.

- HB Hynes, 1975

EXECUTIVE SUMMARY

The Skagway Area Watershed Planning report, prepared for the Skagway Traditional Council, provides a comprehensive assessment of the Pullen Creek watershed within Skagway, Alaska. The study reviews water quality impairments, progress towards attainment, pollutant sources, and management strategies to improve environmental conditions.

Key Findings:

- **Pollution Sources & Impairments:** The primary pollutants impacting Pullen Creek continue to include heavy metals (cadmium, copper, lead, zinc), and polycyclic aromatic hydrocarbons (PAHs). These contaminants stem from stormwater runoff and historical industrial activities. A Total Maximum Daily Load (TMDL) recovery plan for metals in sediment was completed for Pullen Creek in 2010.
- **Watershed Characteristics:** Pullen Creek is an urban drainage system supporting diverse flora and fauna, including salmon species and riparian wildlife. It was designated an impaired waterbody under the Clean Water Act due to heavy metal contamination.
- **Stormwater & Impervious Surfaces:** Impervious surfaces, such as roads and buildings, contribute to water quality degradation by increasing runoff and pollutant loads. Updated stormwater mapping has provided a more accurate understanding of infrastructure and areas requiring improvement.
- **Riparian Buffers:** Vegetated buffer zones are critical for water quality, yet they remain insufficient along Pullen Creek. Increasing buffer coverage by approximately 40-45% would significantly improve sediment filtration and habitat stability.

Management Strategies & Goals:

- **Water Quality Monitoring:** Regular sampling of sediment pollutants and bacteria levels will track progress and inform remediation efforts.
- **Pollution Reduction Measures:** Implementation of best management practices (BMPs), including stormwater treatment infrastructure (e.g., rain gardens, bioswales, green streets), aims to mitigate runoff-related pollution.
- **Riparian Buffer Enhancement:** Expanding and protecting vegetated buffers will increase sediment retention, mitigate heavy metals and PAHs, and improve aquatic habitat.
- **Community Engagement & Policy Development:** Collaborations with the Municipality of Skagway (MOS) and outreach initiatives will promote responsible watershed stewardship and the adoption of regulations supporting buffer protection and stormwater management.

Implementation & Monitoring:

- **Short-Term (2027-2029):** Establish baseline data, conduct monitoring, and initiate riparian and BMP projects.
- **Mid-Term (2030-2035):** Expand remediation efforts, increase buffer zones, and assess pollutant reductions.
- **Long-Term (2035-2040):** Achieve targeted pollutant reductions, sustain monitoring efforts, and refine watershed management strategies.

This plan outlines a science-based approach to restoring Pullen Creek's water quality and ecosystem health while addressing stormwater infrastructure challenges.

A. IMPAIRMENT CAUSES AND POLLUTION SOURCES

A.1 WATERSHED DESCRIPTION

Pullen Creek is an urban drainage system, located entirely within the city limits of Skagway, AK. Skagway lies on the vestigial floodplain of the Skagway River, emptying into the northern Taiya Inlet, and is bordered by the river to the northwest and precipitous mountain terrain to the southeast (ADEC 2010). Located in the Alaska maritime climate zone, Skagway experiences cool dry summers and cold snowy winters. Annual precipitation in Skagway averages around 26.21" (66.57 mm), significantly lower than other areas of Southeast Alaska which range from 58.33" (148.16 mm) in Juneau to 225.53" (572.85 mm) in Little Port Walter (NOAA 2025). This departure from typical Southeast precipitation is due to a rain shadow effect from the coastal mountains south and west of Skagway. 70% of the precipitation received in Skagway is attributed to atmospheric rivers, most intensely occurring between August and October (Nash et al., 2024).

Flora in the Skagway and Taiya River valleys is diverse, particularly lichen species, owing to its position in the coastal mountain rain shadow and an ecotone between the maritime climate of the Alexander Archipelago and the continental climate of the interior just over White Pass. Klondike Gold Rush National Historic Park (KLGO) hosts more than 766 lichen species, more than any other park in the national park system (Drazkowski, Robertson, & Bernatz, 2011). Western hemlock (*Tsuga herterophylla*) and Sitka Spruce (*Picea sitchensis*) are the dominant conifers in the lowlands, accompanied by cottonwood (*Poplus trichocarpa*), Sitka alder (*Alnus viridis ssp. Sinuate*), paper birch (*Betula papyrifera*), and red-osier dogwood (*Cornus stolonifera*) hardwoods (Drazkowski, Robertson, & Bernatz, 2011). Common understory plants are devil's club (*Oplopanax horridus*), rusty menzeisia (*Menziesia furrugeinea*), and blueberry (*Vaccinium spp*.).

The headwaters of Pullen Creek are sourced from three springs: one at the White Pass and Yukon Railroad (WPYR) maintenance yard, another approximately 1.3 miles upstream from the mouth of the creek at 18th street, and the third near the site previously hosting the Jerry Meyers Fish Hatchery 0.85 miles from the mouth (ADEC 2010). The Alaska Power and Telephone (AP&T) Dewey Lakes Hydroelectric Plant also discharges to Pullen Creek at 5th Avenue. The creek harbors spawning chum (*Oncorhynchus keta*), coho (*O. kisutch*), king (*O. tshawytscha*), and pink (*O. gorbuscha*) salmon as well as Dolly Varden (*Salvelinus malma*), and cutthroat trout (*O. clarkii*). Bird species using the riparian corridor include American dippers (*Cinclus mexicanus*), dark eyed juncos (*Junco hyemalis*), bohemian waxwings (*Bombycilla garrulus*), and Steller's jays (*Cyanocitta stelleri*). Mammals utilizing the creek include river otters (*Lontra canadensis*) and American minks (*Neogale vision*).

In addition to wildlife, human visitation is common in the lower reaches of Pullen Creek, due in large part to a 2005 project revitalizing the waterway and the instigation of the Pullen Stream Walk project, a multi-organization effort to increase public access to the creek and educate the community and visitors about the life cycle of Alaska salmon. Phase One of the Stream Walk project was successfully implemented, connecting the Broadway Dock with Pullen Pond, while Phase Two, connecting the existing Stream Walk with City Hall, remains incomplete.

Pullen Creek and the Skagway Harbor were jointly listed as impaired waterbodies in 1990 under Section 303(d) of the Clean Water Act (CWA), due to heavy metal contamination. In 2006, the Alaska

Department of Environmental Conservation (ADEC) separated Pullen Creek from the harbor into its own listing, and this same year the Taiya Inlet Watershed Council (TIWC) compiled the Pullen Creek Action Plan using funding from the U.S. Fish and Wildlife Service (TIWC 2006). Skagway Traditional Council (STC), a federally recognized Tribe in Skagway, drafted the Pullen Creek Waterbody Recovery Plan: Best Management Practices in 2006, outlining steps for stakeholders to take to protect water resources in the urban watershed (STC 2006). ADEC published total maximum daily load (TMDL) values for Pullen Creek in 2010 to restore sediment and water quality to acceptable levels (ADEC 2010). TIWC then published the Stormwater Best Management Practices: Protecting Pullen Creek, an Urban Stream in 2012 (TIWC 2012), and in 2016 STC produced the Pullen Creek Monitoring Project – a 10 Year Comparative Analysis (STC 2016). Screening monitoring took place in 2003-2004, 2015 – 2016, and 2024 at the same five sites to evaluate initial conditions and ascertain remediation impacts (Figure 1). In addition, bacteria screen sampling was conducted in July and August 2024, and microbial source tracking in July 2024.

Figure 1. Overview map of Pullen Creek sampling stations, shown as yellow and black triangles.

A.2 CURRENT CONDITIONS

18 AAC 70.020 outlines water quality criteria for freshwater systems in the state of Alaska for different uses including drinking water supply, recreation, mariculture, and growth and propagation of aquatic life. The state of Alaska has not adopted sediment criteria in 18 AAC 70. Sediment standards in other watershed plans and past studies have been based on the National Oceanic and Atmospheric Administration's Screening Quick Reference Tables (SQuiRT), which were used in the current plan (NOAA 2008).

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) in sediments were screened in 2024, and no previous investigation into this group of analytes in sediment was conducted. The threshold effects limit (TEL) established in the SQuiRTs for total PAHs is set at 264.2 µg/kg, all sites were above the TEL with levels reaching 4372.3 µg/kg at Railyard (Figure 2).[b]

[b] Because the impairment in Pullen Creek is based on elevated levels of metals in bottom sediments, the TMDL establishes sediment quality targets that represent attainment of water quality standards, including designated uses, and sets the loading capacity equal to those targets. The TMDL target and loading capacity are set equal to the toxicological screening level Threshold Effects Low (TEL), presented in the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (Buchman 2008). TELs define chemical sediment concentrations below which toxic effects are rarely observed in sensitive species. A supplemental analysis is included as part of these TMDLs to illustrate that once sediment concentrations meet targets, water column concentrations will also likely decrease and meet applicable water quality criteria.

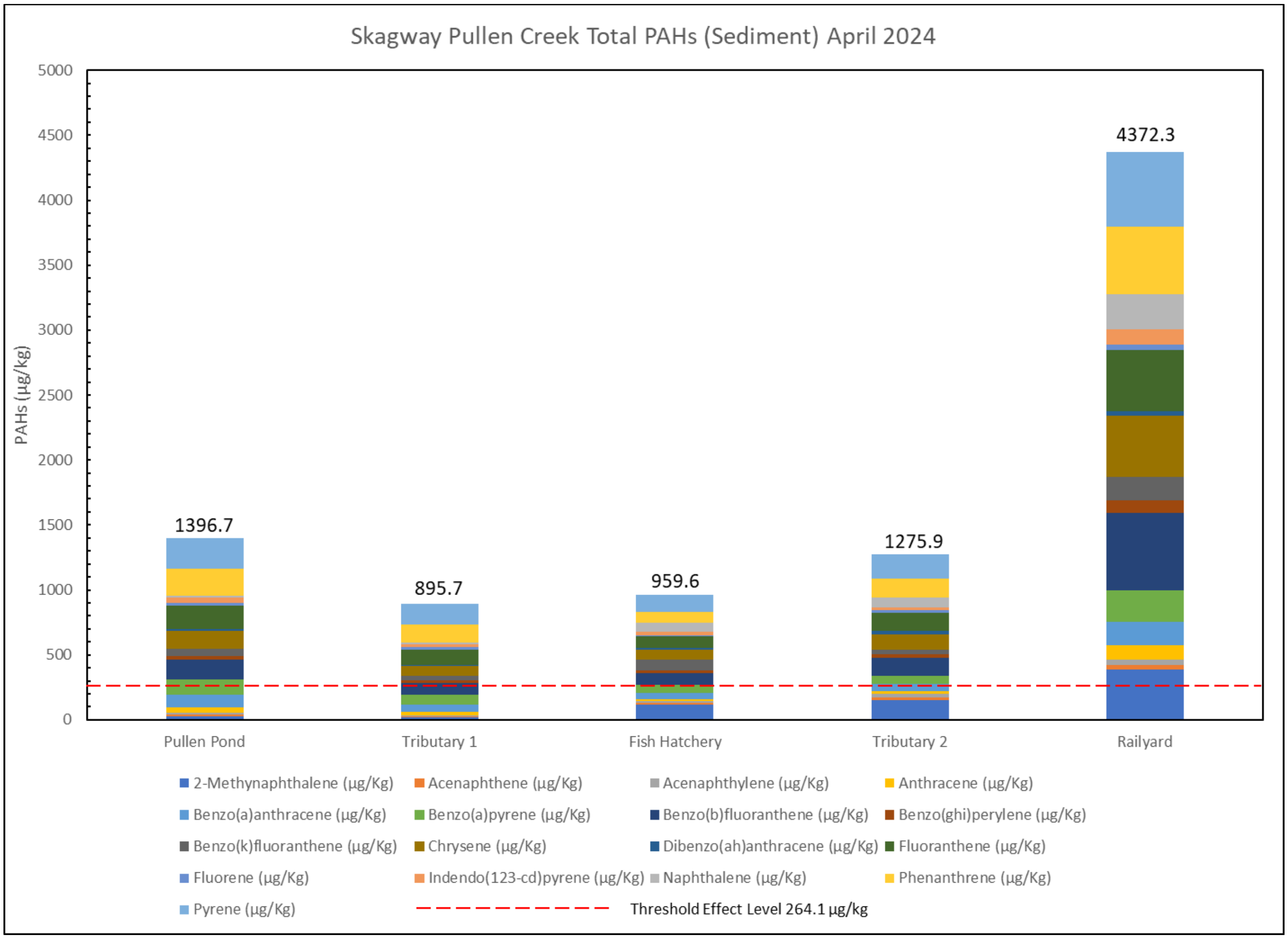

Figure 2. Chart showing levels of total polycyclic aromatic hydrocarbons at five locations on Pullen Creek, April 2024.

Sediment Heavy Metals

Sediment heavy metals in Pullen Creek between 2004 and 2024 consistently exceeded loading capacity of TMDLs established in 2010, particularly cadmium, copper, lead, and zinc (Figure 3, A - G). Instead of increasing with magnitude moving downstream in the system, concentrations were highest at the two farthest upstream sites (Tributary 2 and Railyard), suggesting a contaminant source close to these locations. Comparison to previous studies shows that many metals' concentrations have decreased since 2004, potentially reflecting the success of implemented best management practices (BMPs) outlined in Pullen Creek Waterbody Recovery Plan – Best Management Practices. The reduction of heavy metals concentrations suggests that some of these BMPs may have been effectively administered.

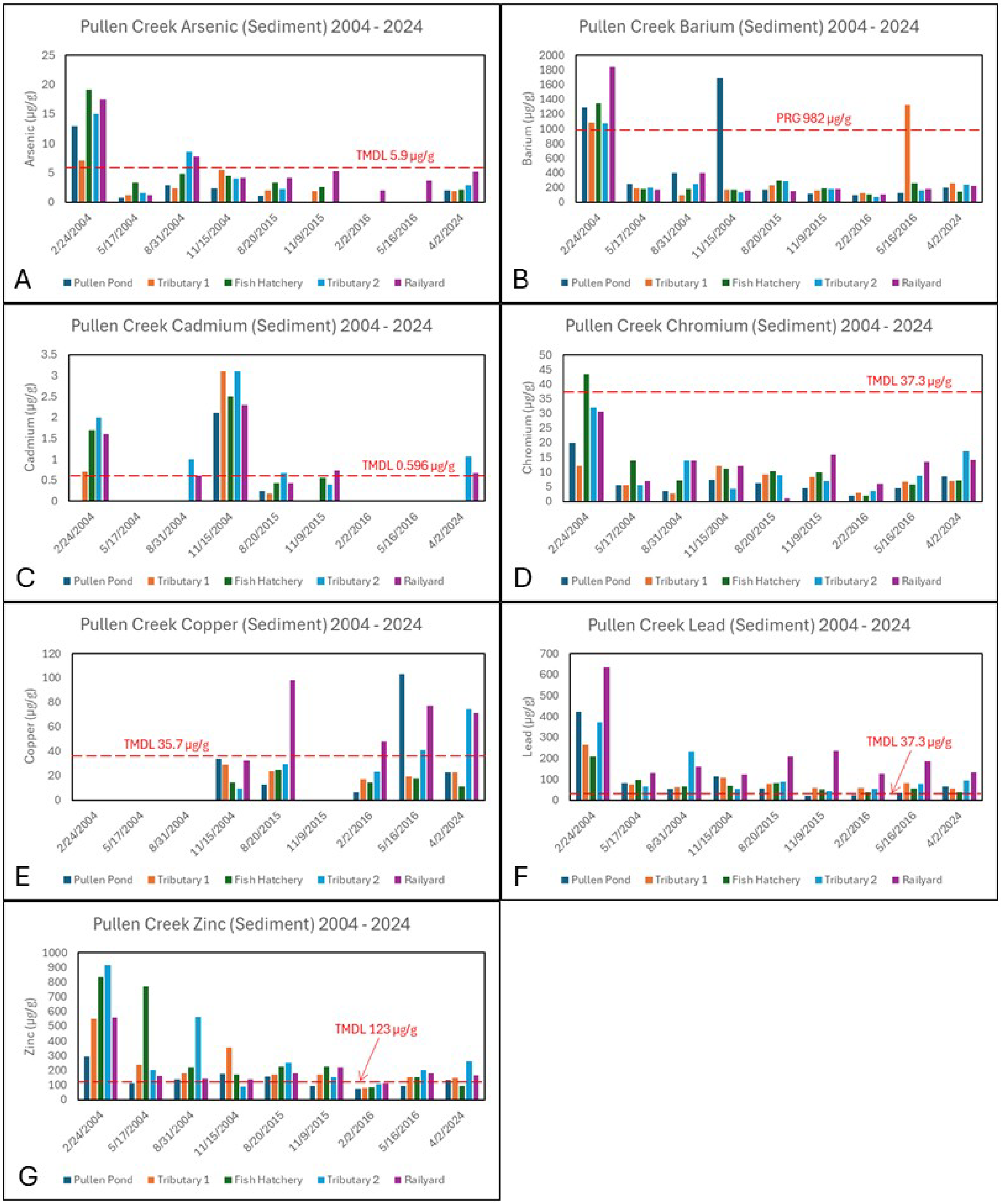

Figure 3. Matrix of heavy metal sediment results from Pullen Creek sampling, April 2024.

Bacteria

Bacteria sampling took place in July and August 2024, quantifying *E. coli* and fecal coliforms at three of the five established sites (Railyard, Tributary 2, and Pullen Pond). Results were mainly below WQS, however a single datapoint at Pullen Pond exceeded the limit for drinking water (58 CFU/100 mL, 8/7/24; Figures 4 & 5). It should be noted that the sampling period was during the dryer summer months with minimal precipitation and stormwater runoff, potentially missing bacteria loading from stormwater inputs.

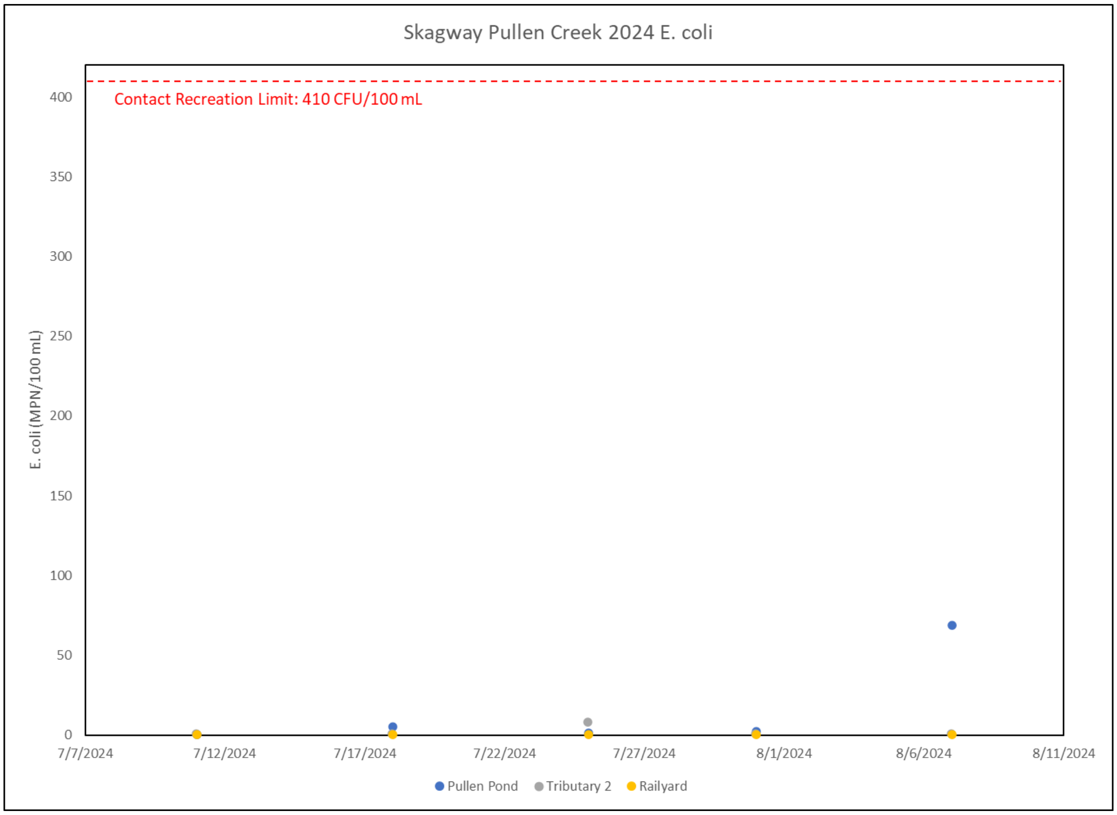

Figure 4. Pullen Creek E. coli analytical results, 2024, all sites.

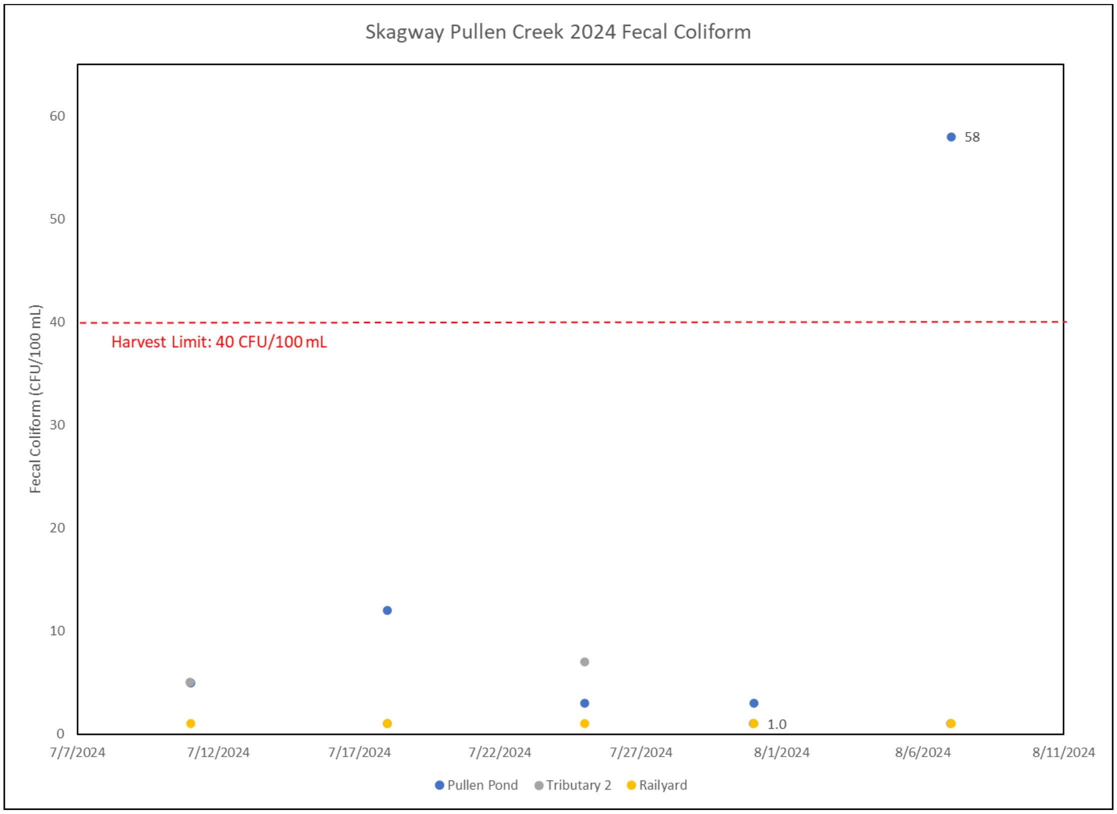

Figure 5. Pullen Creek fecal coliform analytical results, 2024, all sites.

Riparian Buffers

Riparian buffers are zones of vegetated land bordering creeks and other waterways, known to aid in reducing sedimentation and improving water quality (Walter et al. 2009). This is achieved through the alteration of surface water input flows that facilitates sediment trapping within the above-ground woody parts of plants (stems, stolons, etc.), uptake of excess nutrients by riparian plants, and the provision of bank stabilization through root establishment which reduces sediment inputs from in-situ erosion (Polyakov, Fares, & Ryder 2005). Recommendations on the minimum required size of riparian buffers vary widely, ranging on average from approximately 30-100 feet across a host of jurisdictions (Walter et al. 2009). The Municipality of Skagway does not have regulations governing riparian buffers; however, the Skagway Coastal Management Plan references the Alaska Coastal Management Program (ACMP) standard of 100-foot buffers on either side of single channel streams and rivers (City of Skagway 2007). The nearby urban center of Juneau has adopted codes regulating riparian buffer zones, with no development allowed within 50 feet of stream banks, and any disturbance is prohibited within 25 feet (CBJ § 49.70.310, 320, and 330). CBJ § 49.70.310 and 330 dictate that all structures have a 50-foot setback from streams which must be vegetated to the extent that maximizes stream shading. The 2012 Stormwater Best Management Practices manual for Pullen Creek recommends a 10-foot buffer. For the purposes of this document, Skagway riparian buffers are compared to the 10-foot buffer recommended from the BMP manual and the 25-foot Juneau standard for assessment.

To examine the state of Pullen Creek riparian areas, Light Detection and Ranging (LiDAR) deliverables were analyzed in geographic information system (GIS) software. LiDAR acquisition is a method for developing digital elevation models (DEM) for various management processes and is achieved by analyzing the reflection of laser bursts originating from an aerial vehicle and aimed at objects on the ground. The return time provides a distance estimate, and when coupled with the elevation of the laser source these data produce a high-resolution model of ground, building, and vegetation height. LiDAR was flown by the Alaska Department of Natural Resources (DNR) in July 2023, and the dataset created was provided to STC in early 2025 (Dewberry 2025). Raw LAS (LASer) files were imported to ESRI ArcPro GIS software after converting from the delivered and compressed LAS Zipped (LAZ) format, and the classified point cloud was filtered to produce a bare earth model and surface models including all trees and buildings (ESRI 2025). A canopy height model (CHM) with buildings removed was derived from these deliverables using the Raster Calculator geoprocessing tool. The DNR dataset contained substantial noise - small artifacts, false readings, and improperly classified points – which was partially mitigated by using the Raster Calculator tool to isolate elevations above 1.5 meters; however, dataset noise likely contributes to a misrepresentation of actual tree cover. The filtered CHM was automatically digitized with the Raster to Polygon tool creating a model of canopy cover in Skagway (Figure 6).

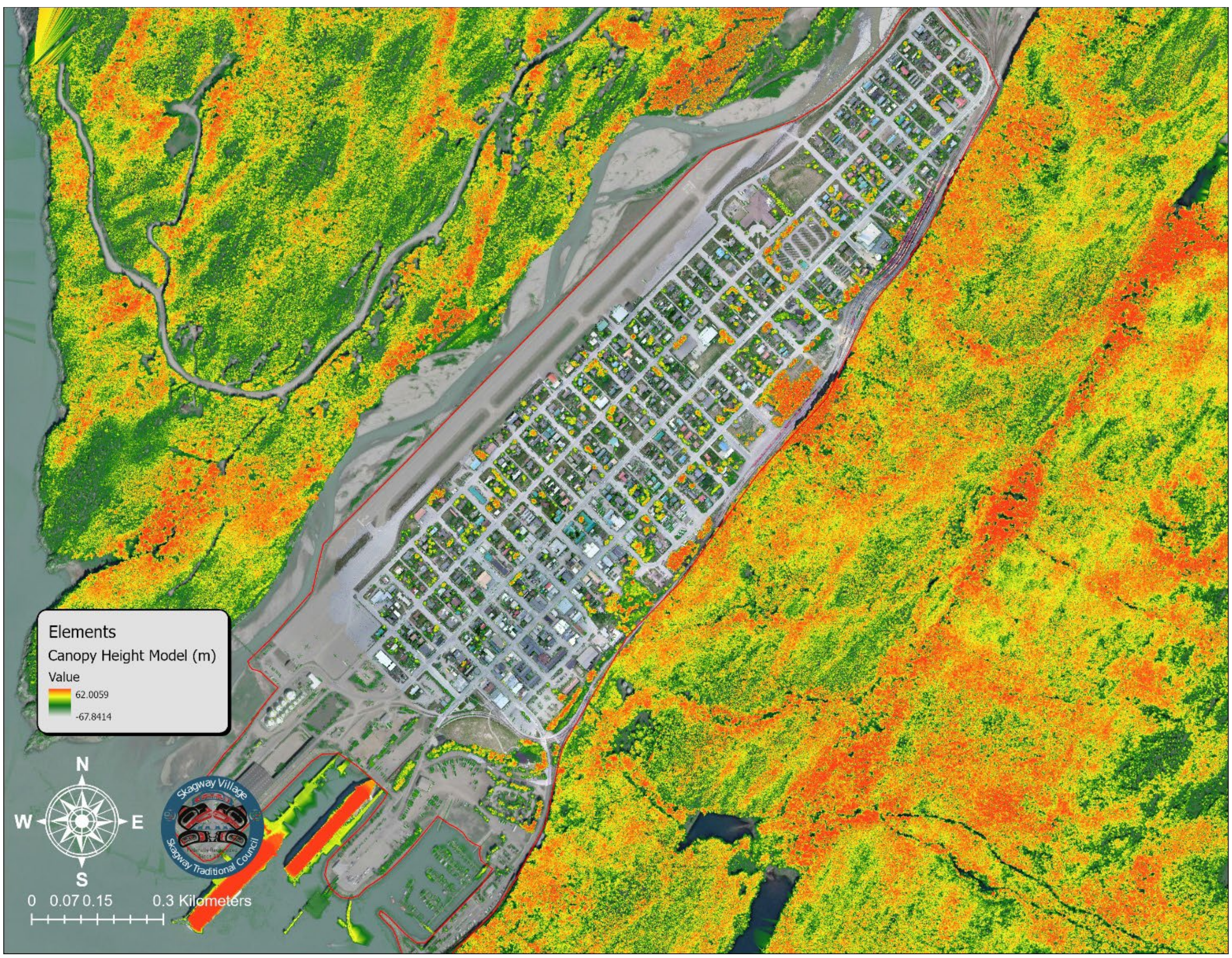

Figure 6. Canopy height model focused on Pullen Creek, showing elevation of vegetation, Skagway, AK.

The bare-earth DEM was hydro conditioned and processed using the Agricultural Conservation Planning Framework (ACPF) toolbox within the ArcPro environment (Porter et al., 2015). Hydro conditioning included using the manual cutter and dam builder to model Pullen Creek culvert crossings, visualizing impoundments based on the DEM, and running the model through several iterations to achieve the most accurate flow lines for the creek. Once this was complete, the mainstem of Pullen Creek was manually digitized using standard editing tools and the hydro conditioned flow lines from the previous process, and two polygon buffers were created using the Buffer tool: 10 feet from stream center, and 25 feet from stream center. The canopy model polygons were clipped to each of the buffer polygons using the Clip tool, and the total acreage of both buffers and the clipped canopy polygons were calculated within ArcPro. Culvert crossings and adjacent roadways were removed from the analysis using the Split tool.

Results from this analysis are shown in Table 1. With consideration of the data limitations described above, to achieve the most complete riparian buffers along Pullen Creek within the suggested zones of 10 and 25 feet, canopy cover would need to increase by 40-45%. Rooftops and other impervious surfaces within the riparian zone help to route overland flow potentially laden with pollutants directly to Pullen Creek. These results should be inventoried and mitigation strategies developed for future BMP opportunities.

Table 1. Riparian buffer metrics for Pullen Creek, 2025.

Buffer Size in feet	Area of Buffer in Acres	Area of Trees in Acres	Percent Canopy Cover
10	4.34	2.80	64.5 %
25	10.51	6.38	60.7 %

Figure 7. Selection of riparian coverage mapping along Pullen Creek, Skagway, AK

Stormwater Mapping

TIWC mapped Skagway's stormwater infrastructure and assets in 2006, to date this document is the most comprehensive inventory and delineation of the system available. Many updates have been implemented since 2006 and the original metadata associated with the dataset have been lost. STC updated the map and metadata in 2023.

A Trimble R1 receiver mounted to a prism pole with a level indicator and paired with an Apple tablet was used to collect geospatial data. A basemap of the TIWC data was created and loaded onto the tablet for reference. Staff visited catch basins and outfalls and completed individual site surveys for each location based on the asset type. Attributes such as pipe direction, basin geometry, depth to pipe, grate condition and shape, pipe size and material, presence of contaminants and sediment, water condition, and estimated contributing area impervious surface were collected. Pipe direction attributes were used to create a symbology layer showing pipe directions on the map, enabling staff to digitize probable beneath-ground stormwater pipes.

Final disposition of stormwater pipes could not be determined. STC submitted a public records request to MOS in September 2024, the request did not yield any documents showing the final disposition of stormwater. MOS Public Works was contacted, they did not have the information. As-built technical drawings were supplied by AKDOT, however these did not contain the information needed. Another shapefile was created in ArcPro called Speculative Pipes, showing the best guess for final stormwater disposition. This was sufficient to complete the step in the following section, however more accurate knowledge of stormwater connections will be necessary for future investigations.

The updated stormwater map can be found in Appendix A.

Mapping Pullen Creek Watershed

The contributing areas of the Pullen Creek watershed have not been accurately delineated with consideration for the stormwater system and other infrastructure, making inferences about watershed activities difficult. Understanding the geographical extent of Pullen Creek's watershed is paramount for management decisions, therefore a process was executed to roughly perform this delineation.

In the ArcPro environment and using outputs from the ACPF toolbox, watershed limits were determined from DEM-derived contour and flow lines. Automated tools could not be used due to the incorporation of below-ground stormwater infrastructure to the system, complicating the typical watershed delineation workflow. Basic editing tools were used to create a new polygon, which was hand-digitized to reference markers and stored in the project geodatabase. General attributes such as shape size and area were generated within ArcPro.

A map of the Pullen Creek watershed can be found in Figure 8. It should be noted that the United States Geological Survey (USGS) National Map shows boundaries for Pullen Creek that extend into the Upper Dewey Lake watershed, however the hydrological connection between the Alaska Power and Telephone (AP&T) hydroelectric plant and associated reservoir is limited to a penstock input and was not included in this analysis. More comprehensive watershed modeling should be employed to determine final watershed boundaries.

Figure 8. Overview map of the Pullen Creek watershed, outlined in yellow, with trees shown as green polygons.

Impervious Surfaces

Impervious surfaces in the Pullen Creek watershed were hand-digitized using a UAS imagery dataset as a base layer collected by the University of Washington Natural Hazard and Disaster Reconnaissance Facility (known as RAPID) (Wartman et al. 2020). Individual imagery files were imported to Open Drone Map for photogrammetry processing and an orthorectified imagery model of Skagway was created (ODM 2025). Assumptions were as follows:

- Roads, structure rooftops, permanently parked vehicles, gravel driveways, all types of parking lots, and railroads were assumed to be impervious.
- Selections were binary and non-ordinal, i.e. pervious vs impervious; roads were not considered more impervious than gravel parking lots.
- Rooftop anomalies from photogrammetry were geometrically corrected.
- Areas within gravel lots with vegetation growing through were assumed to be pervious.
- Tree canopies over concrete were not included, only the estimated base area with pervious soil.
- Bare rock faces outside the urban area were marked as pervious.

Once all surfaces were digitized and classified, polygons of pervious and impervious surfaces were clipped to the newly created Pullen Creek watershed boundary. Area in US acres was calculated for the total watershed and each surface class. Results from this analysis can be seen in Table 2 and Figure 9.

Table 2. Summary of Pullen Creek impervious surfaces, Skagway, AK.

Type	Area in Acres	Percent of Watershed
Pullen Creek Watershed	390.83	100.00 %
Impervious Surfaces	72.49	18.55 %
Pervious Surfaces	318.33	81.45 %

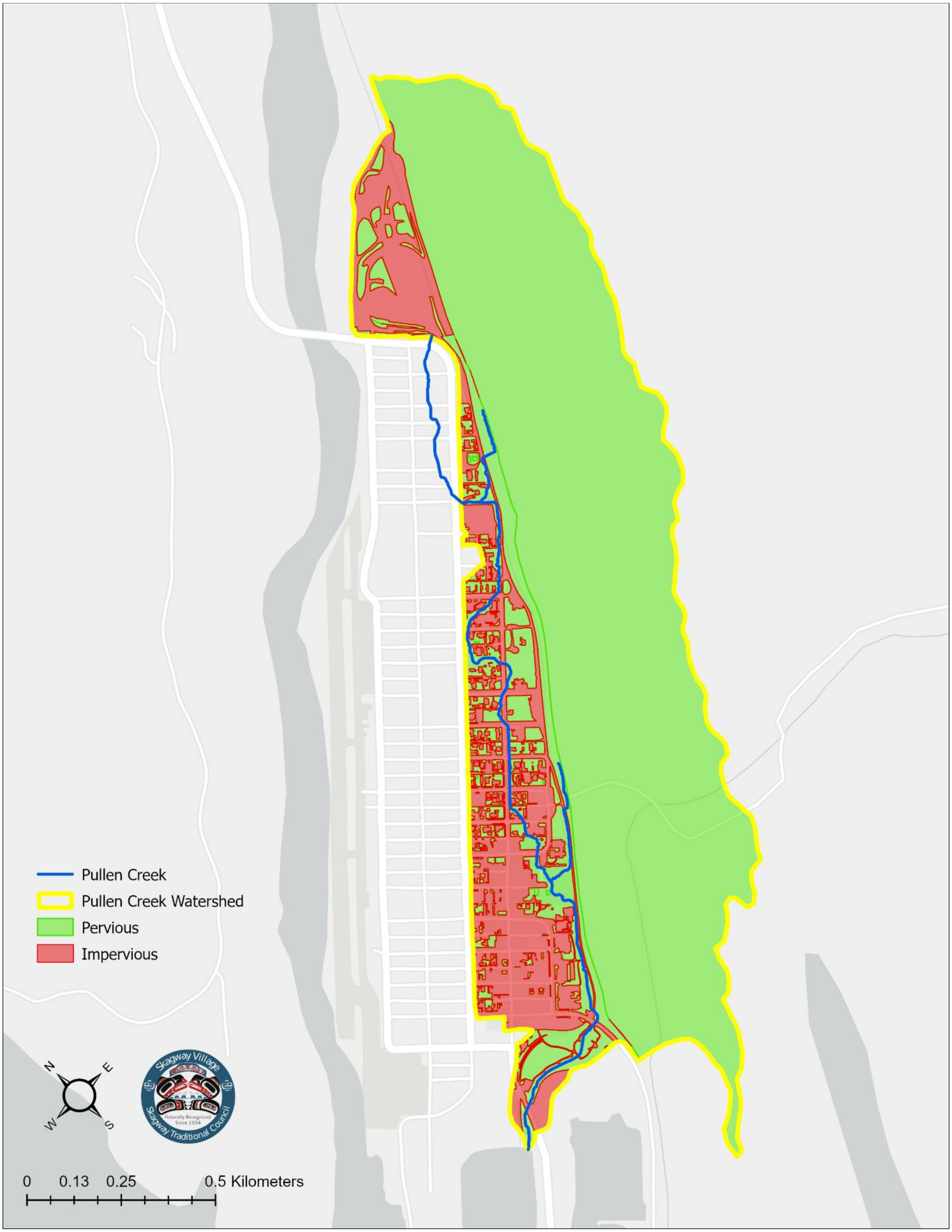

Figure 9. Overview map of the Pullen Creek watershed, outlined in yellow, with pervious surfaces shown as green polygons and impervious surfaces as red polygons.

B. POLLUTANT LOADING AND EXPECTED LOAD REDUCTIONS

A comparison of the 2024 screening sampling to past investigations suggests that heavy metal concentrations in sediment have decreased over time, however cadmium, copper, lead, and zinc levels remain above loading capacity. These metals are commonly associated with stormwater inputs and industrial discharge. Sediment PAHs were above loading limits set by the TMDLs and are also thought to be a product of stormwater inputs. To estimate pollutant loading and expected reductions, comprehensive data on stormwater pollutant concentrations and stream discharge must first be obtained. These data are not currently available and should be collected.

As an alternative to pollutant loading and reduction estimates, this section will outline the impact of suggested improvements to riparian cover and potential BMP sites, based on total watershed area, intact riparian buffers, and impervious surfaces.

For riparian areas, the prescribed 10-foot buffer is used for metrics, and it is assumed that at 100% coverage the effects of overland flow will be mitigated. This is an oversimplification as many factors will influence sediment load reduction, but for preliminary purposes it will serve as a surrogate. The 10-foot buffer along Pullen Creek, excluding road crossings, is approximately 4.34 acres with 2.8 acres adequately vegetated. Increasing riparian cover by 44.5%, or 1.54 acres, is the ultimate goal.

For impervious surfaces, the Washington Rain Garden Handbook (Hinman 2013) suggests a range of percentage values to mitigate runoff based on soil drainage rates, ponding depth, and effectiveness. Skagway is located on the vestigial alluvial fan of the Skagway River with good drainage, it is assumed that soils in the valley drain at 1.00 – 2.49 inches/hour. With an estimated ponding depth of 12” and the lowest of three performance levels selected, a modest estimation of 10% of the acreage of impervious surfaces should be converted to nature-based stormwater solutions (NBS) to alleviate the effects of runoff. The total area of the Pullen Creek watershed is 390.83 acres, with impervious surfaces making up 72.49 acres. Installing 7.25 acres of rain gardens or other NBS is the goal.

Watershed Plan Goals

1. Meet sediment loading limits from TMDL for metals and TELs for PAHs.
2. Evaluate current bacteria levels.
3. Increase riparian buffers where possible and keep existing riparian buffers intact.
4. Increase NBS in the community to capture and treat stormwater runoff before reaching Pullen Creek.
5. Engage with MOS to update stormwater mapping including the final disposition of stormwater.
6. Develop inventory and mitigation strategies for future BMP opportunities.
7. Complete Phase Two of the Pullen Creek Stream Walk project connecting the existing Stream Walk with City Hall.
8. Evaluate watershed modeling to determine final watershed boundaries.

C. MANAGEMENT MEASURES

Much of the work needed requires collaboration with the Municipality of Skagway since the Pullen Creek watershed lies entirely within its jurisdiction and the city manages the stormwater system, one of the primary suspected sources of pollutant loads. The following lists contains suggested management measures.

1) Preliminary Measures
   a) Conduct bacteria monitoring at established sites and select stormwater outfalls to determine background and urban watershed bacteria levels.
   b) Conduct baseline and stormwater monitoring at established sites and select stormwater outfalls to determine event mean concentrations for Skagway storm events.
   c) Work with MOS to identify required permits, committee protocols, MOU/MOA generation, and easements for both municipal and private NBS installations, establish city code on riparian buffers and a MOS supported kickback program for private NBS installations.
   d) Collect spatial data for the watershed model.
      i) Perform a culvert survey for Pullen Creek.
      ii) Refine riparian mapping with ground truthing.
      iii) Refine impervious surface mapping with ground truthing and establish ordinal categories.
      iv) Update stormwater pipes shapefile with final disposition of unknown stormwater pipe routing, using biodegradable dye either during storm events or in coordination with the Skagway Fire Department.
   e) Revise watershed model with ground truthed data
      i) Input new data into the watershed model and revise riparian, impervious surface, and watershed boundary models and geospatial statistics.
      ii) Build surface and subsurface networks and generate contributing areas for complete Skagway stormwater system and Pullen Creek.
2) Community Measures
   a) Contact Pullen Creek landowners and discuss riparian enhancements and funding sources for improvements.
   b) Contact landowners within the Pullen Creek watershed to discuss residential BMPs such as rain barrels and gardens, and funding sources for improvements.
   c) Provide outreach to Skagway residents on environmentally friendly car washing, landscaping, and pet waste management techniques.
   d) Provide outreach to Municipal staff and elected officials outlining the available resources from the State Revolving Fund for municipal water infrastructure improvements.
3) Municipal Riparian Measures:
   a) Improve the buffer east of City Hall on Spring Street and 7th Avenue by planting shrubs and deciduous/coniferous trees.
   b) Improve the buffer north of the Public Safety Building on State Street and 18th Avenue by planting shrubs and deciduous/coniferous trees.
   c) Protect and enhance the intact riparian buffer between City Hall and 5th Avenue by planting coniferous trees beneath the canopy.
4) Municipal BMP Measures:

a) Perform infiltration tests and reinstall NBS at 11th and Broadway. To address neighborhood and municipal concerns about the safety of NBS depressions and curb cuts, backfill NBS to sidewalk level and install metal inlet grates.
b) Install NBS at the corner of Spring Street and 7th Avenue beneath the boardwalk to intercept overland flow prior to entering the stormwater system.
c) Install NBS at the corner of Broadway and 9th Avenue in the green belt between the sidewalk and street, following the design of the NBS at 11th and Broadway to limit pedestrian hazards and vehicle tire damage.
d) Install NBS on Spring Street between 9th and 10th Avenues in the gravel strip between the street and the greenbelt.
e) Perform infiltration tests and complete plant inventory every 5 years at each NBS installation to monitor effectiveness of BMP.
f) Evaluate pet waste station locations and install new where necessary.
g) Install interpretive signage at new NBS installations.
h) Engage with MOS, WPYR, the National Park Service, and other stakeholders to complete Phase 2 of the Pullen Creek Stream Walk, connecting the existing trail between Congress Way and the Dewey Lakes trail system with City Hall.

D. TECHNICAL AND FINANCIAL ASSISTANCE

The described measures can be funded through various revenue streams, primarily the Alaska Clean Water Actions (ACWA) grant through ADEC, and the Indian General Assistance Program (IGAP) grant through the Environmental Protection Agency (EPA). Many of the measures will only require staff time, such as any process for acquiring permits and committee approvals. More intensive measures such as rain garden design and installation will need more resources and partners to successfully implement.

Table 3. Outline of proposed projects with information on stakeholders, funding sources, and required resources. Cost symbols represent the following categories: $ = < $1000; $$ = $1000 - $5000; $$$ = $5000 - $15000; $$$$ = > $15000

Measure	Lead	Partners	Cost/Source	Resources
1(a)	STC	ADEC, SAWC	$$/EPA	Sample plan, MOS permit, QAPP
1(b)	STC	ADEC, MOS, SAWC	$$/EPA	Sample plan, MOS permit, QAPP
1(c)	STC	MOS, SAWC	$/EPA	MOS permits, committee approval, MOS approval, MOU/MOA
1(d)	STC	ADEC, MOS, SAWC	$$/ADEC, EPA	Field protocols, MOS permit
1(e)	STC	MOS	$/EPA, MOS	Field data
2(a)	STC	SAWC, SDC	$/ADEC, EPA	Landowner database
2(b)	STC	SAWC, SDC	$/ADEC, EPA	Landowner database
2(c)	STC	SAWC, SDC	$/ADEC, EPA	Design plans, committee approval, MOS permit
2(d)	STC	ADEC, MOS, SAWC	$/ADEC, EPA	SRF literature
3(a)	STC	ADEC, MOS, SAWC	$$/ADEC, EPA, MOS	Design plans, plant genetics
3(b)	STC	ADEC, MOS, SAWC	$$/ADEC, EPA, MOS	Design plans, plant genetics
3(c)	STC	ADEC, MOS, SAWC	$$/ADEC, EPA, MOS	Design plans, plant genetics
4(a)	STC	ADEC, MOS, SAWC	$$$/ADEC, EPA, MOS	Design plans, committee approval, MOS permit
4(b)	STC	ADEC, MOS, SAWC	$$$/ADEC, EPA, MOS	Design plans, committee approval, MOS permit
4(c)	STC	ADEC, MOS, SAWC	$$$/ADEC, EPA, MOS	Design plans, committee approval, MOS permit
4(d)	STC	ADEC, MOS, SAWC	$$$/ADEC, EPA, MOS	Design plans, committee approval, MOS permit
4(e)	STC	ADEC, MOS, SAWC	$/ADEC, EPA	Sample plan, QAPP
4(f)	STC	ADEC, MOS, SAWC	$$/ADEC, MOS	Inventory of stations, MOS permit
4(g)	STC	ADEC, MOS, SAWC	$$/ADEC, MOS, EPA	Sign design, MOS permit
4(i)	STC	ADEC, NPS, MOS, USFWS, WPYR	$$$$/ADEC, EPA, MOS, USFWS	Design plans, committee approval, MOS permit

E. EDUCATION AND OUTREACH ACTIVITIES

Outreach is a critical component of this plan, because engagement with citizens and city managers will be paramount in determining acceptable areas to perform the work and increase acres where mitigation takes place. Additionally, engagement and education about the stream ecosystem will help to impart a feeling of stewardship to landowners, which would increase the chances of a successful and enduring outcome.

- Completed Public Outreach
    - Skagway school stormwater workshop with K-5 students 2023.
    - Skagway Recreation Center riparian vegetation outreach 2024.
    - Community invasive plant species outreach 2024.
- Suggested Public Outreach
    - Outreach on BMPs, targeted at municipal Public Works employees, contractors, and private citizens.
    - Outreach on riparian buffers within private parcel boundaries, targeted at landowners whose properties contain reaches of Pullen Creek.
    - Outreach on the impact of impervious surfaces and benefits of nature-based stormwater solutions in two tiers: one for municipal employees and elected officials, and another for private citizens.
    - Residential best management practices outreach, teaching homeowners techniques for reducing their impacts on the stream environment.
    - Residential NBS outreach, teaching homeowners basic maintenance for their installations.
    - Municipal State Revolving Fund outreach, informing municipal staff and elected officials of funding opportunities and resources for improving municipal water infrastructure.

F. PROJECT SCHEDULE

The following schedule summarizes the timing of measures described in Section C. Committee approvals and permitting may take longer than estimated, however the schedule gives the best estimate of when each component of the plan will take place. A review of progress and revision of this schedule will take place every year.

Table 4. Project schedule.

Measure	2027	2028	2029	2030 - 2035	2036 - 2040
1(a)		X			
1(b)		X			
1(c)		X			
1(d)	X				
1(c)	X				
2(a)	X	X	X	X	X
2(b)	X	X	X	X	X
2(c)	X	X	X	X	X
2(d)	X	X	X		
3(a)			X		
3(b)			X		
3(c)			X		
4(a)				X	
4(b)				X	
4(c)					X
4(d)					X
4(e)					X
4(f)				X	
4(g)					X
4(i)					X

G. MILESTONES

Repeated monitoring of sediment pollutants, riparian buffers, and installed NBS will provide data to evaluate targets in the following table.

Table 5. Summary of project milestones (targets).

Indicator	2030 Target	2035 Target	2040 Target
PAHs (sediment)	Levels are below 2024 results	Levels are below 2030 results	Levels are below loading limits
Chromium (sediment)	Levels are below 2024 results	Levels are below 2030 results	Levels are below TDML
Copper (sediment)	Levels are below 2024 results	Levels are below 2030 results	Levels are below TDML
Lead (sediment)	Levels are below 2024 results	Levels are below 2030 results	Levels are below TDML
Zinc (sediment)	Levels are below 2024 results	Levels are below 2030 results	Levels are below TDML
Riparian Vegetation	Updated riparian inventory	0-10 feet, increase coverage by 0.5 acres	0-10 feet, increase coverage by 1.54 acres
NBS	Updated impervious surface inventory	Increase NBS by 0.5 acres, monitor effectiveness	Increase NBS by 7.25 acres, monitor effectiveness

H. PROGRESS INDICATORS

To assess progress, Table 6 describes progress indicators to be evaluated by project staff, following the schedule in Sections F and I.

Table 6. Progress indicators and criteria for evaluation.

Indicator	Criteria
PAHs (sediment)	Periodic sampling of the five sites previously investigated, analyzed by a DEC qualified lab.
Chromium (sediment)	Periodic sampling of the five sites previously investigated, analyzed by a DEC qualified lab.
Copper (sediment)	Periodic sampling of the five sites previously investigated, analyzed by a DEC qualified lab.
Lead (sediment)	Periodic sampling of the five sites previously investigated, analyzed by a DEC qualified lab.
Zinc (sediment)	Periodic sampling of the five sites previously investigated, analyzed by a DEC qualified lab.
Riparian Vegetation	Riparian inventory as documented through periodic assessments.
NBS	Acres of installed rain gardens, bioswales, and infiltration basins, assessed after each working year.
NBS Effectiveness Monitoring	Periodic infiltration testing and vegetation inventory.

I. MONITORING

Monitoring is one of the most important aspects of this plan, as current baseline bacteria levels and event mean concentrations for chromium, copper, lead, and zinc in sediment are unknown. Obtaining this information along with more robust riparian and impervious surface inventories will help to create more accurate pollution loading and reduction models for future iterations of the watershed document.

Table 7. Summary of monitoring activities and timelines.

Indicator	Description of Activities
PAHs (sediment)	Sample 5 sites every 5 years
Chromium (sediment)	Sample 5 sites every 5 years
Copper (sediment)	Sample 5 sites every 5 years
Lead (sediment)	Sample 5 sites every 5 years
Zinc (sediment)	Sample 5 sites every 5 years
Bacteria (water)	Sample 5 sites every 5 years, sample 3 outfalls after 3 different storm events
Riparian Vegetation	Assess riparian cover every 5 years, document improvements
Impervious Surfaces	Assess impervious surfaces every 5 years, document NBS installations and keep a running tally of impervious and NBS acres.
NBS Effectiveness	Perform infiltration tests every 5 years, document plants within NBS every 5 years.

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APPENDIX A. UPDATED STORMWATER MAP

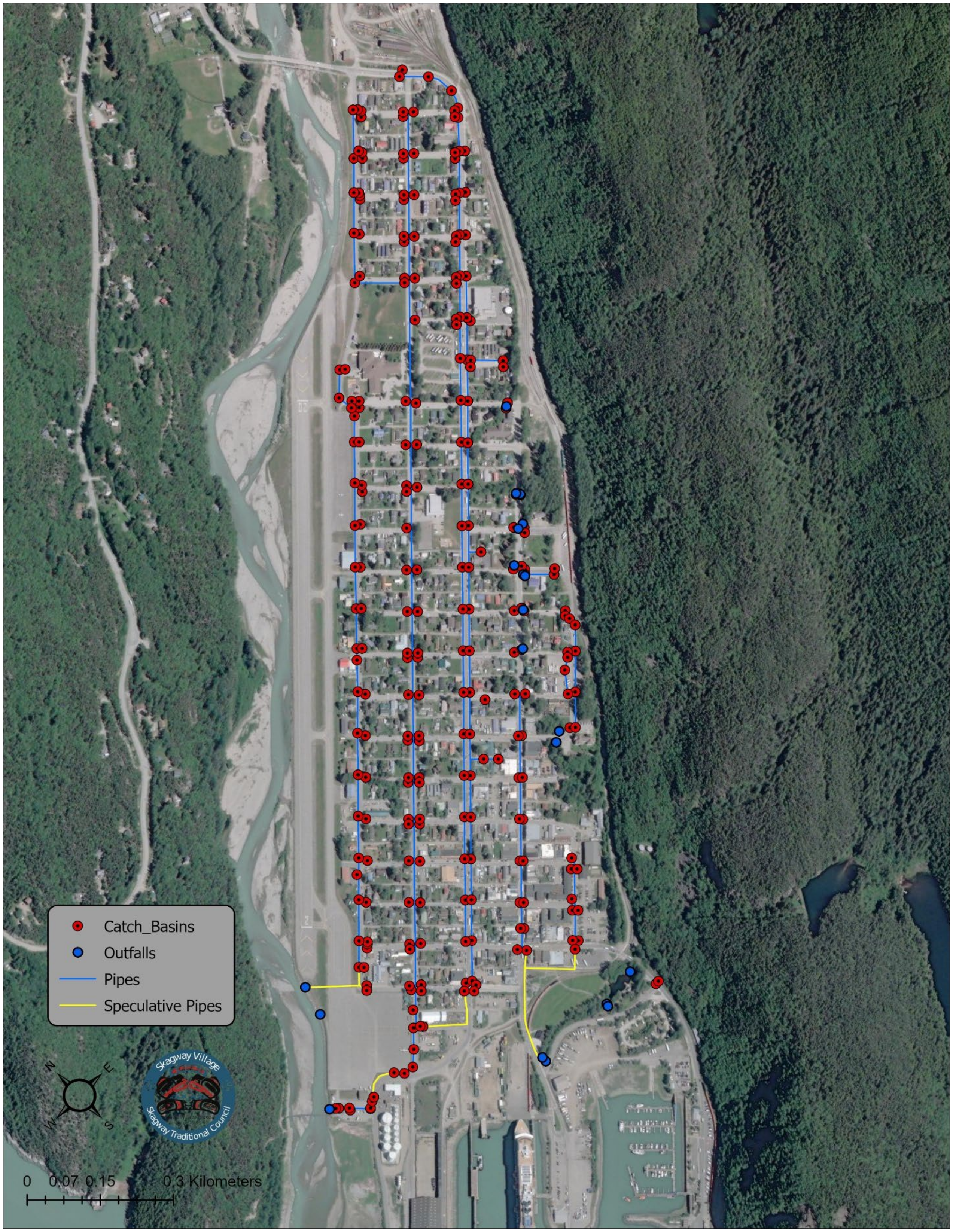

Figure 10. Overview map of stormwater infrastructure in Skagway, AK, 2024.